Seed dispersal pattern and germination test of *Rhodiola sachalinensis*

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Abstract: The survey of seed dispersal of *Rhodiola sachalinensis* was carried out in Changbai Mountain in 1997. It was discovered that the dispersal of seed is not equal in all directions, but concentrates in the East and North to the cluster. *Rh. sachalinensis* seeds for germination test were collected from Changbai Mountains area (Antu County, Jilin Province) and Dahailin Migrating Conservation Base (Dahailing Forestry Bureau, Heilongjiang Province). The seeds were treated with 2% KNO_3 for 10h and 0.02% GA_3 for 5h immediately after the collection. The germinating rate ((85.33%) of the seeds from Dahailin was obviously higher than that (72.66%) from Changbai Mountains. After being stored at 0-5 °C for 10 months, the seeds were treated again with the same concentration of hormone mentioned above for germination test. The experimental results showed that there was almost no difference in germinating rate between newly collected seeds and 10-month storage seeds, which indicated that low-temperature storage can extend the life of seeds, and that the germinating rate increases with increasing of hormone concentration.

Key words: *Rhodiola sachalinensis*, Seed dispersal, Seed germination

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Introduction

Rhodiola sachalinensis is an herbal species belonging to *Rhodiola*, Crassulaceae. It exhibits a strong adaptability to the climate at high elevations from 1 700 to 2 500m (Zhang 1993). As a medicine plant species, *Rh. sachalinensis* functions in anti-caducity, intellect recovery, the physical power strengthening etc (Wu 1987). However, due to its narrow distribution area, low economic reserves, and over active harvest, the natural reserves decreased very quickly, and *Rh. sachalinensis* became an endangered species (Fu *et al.* 1989, 1992, Qin *et al.* 1993).

The dispersal and spread of reproductive body is the most important way to form and extend a population. The number, distance and laws of reproductive body dispersal is not only regarded as the base for understanding dynamics of population and community, but also considered as important problem in evolution ecology involving the ecological adaptation and population countermeasures (Zhu 1992). The final purpose of reproductive body dispersal and spread is to seek for the most suitable ecological space, though different species might adopt different mechanisms and patterns in the dispersal process.

With long-term natural selection, the fruit and seed of plants formed various morphological characters adapting to various mediums of dispersal, Which are benefits to disperse extend the space of individuals, and enhance the population booming. The seed of *Rh. sachalinensis* is small in size and weight and attached with a membrane wing at the top. These characteristics benefit the dispersal through wind.

Rhodiola sachalinensis has strong ability to generate clones. However, the clone individual cannot leave the cluster, so it has no contribution to the spread of population. Seed dispersal is the only way of *Rh. sachalinensis* to extend the population space. Therefore, the pattern and distance of seed dispersal of *Rh. sachalinensis* become the central questions to understand its renewal, dispersal and space distribution of population.

Materials and methods

The field experiments were conducted in Changbai Mountains area that spans 41°23'-42°36'N and 126°55'129°E. This area belongs to the mountainous climate in temperate continent. Annual temperature averages 3-7°C, and the average temperature in July and January is 8.7°C and -23.3 °C respectively. Accumulated temperature above 10°C is 1 928.6-2 788.8 °C, while it is only 122.6 °C on the top of Changbai Mountains. Frost-free period lasts 64-74d. The annual precipitation is in the range of 600-1 340 mm, concentrating in July and August, with an annual maximum precipitation of 1 809

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mm. The average relative humidity is between 65%-74%.

In late August 1997, when the seeds of *Rhodiola sachalinensis* have dispersed totally, 4 separately growing clusters were selected as experimental individuals. Radiant lines along south, west, north, and east directions from the root of the clusters were designed as sampling transects. 20 sampling units (10cm x10cm each) were defined on each direction. The number and average height of reproductive branch and the root diameter for each of four clusters were recorded (Table 1). Soil samples was collected at a depth of 1 cm in each sampling unit and washed in sieves (hole area 0.01 mm^2) to separate the seeds. The average number of seed per unit distance from the root was calculated based on the data of 4 clusters.

Table 1. Basic investigation information of 4 selected clusters of *Rhodiola sachalinensis*.

Sample of Cluster.	Number of branch	Average height (cm)	Average root diameter (cm)
No. 1	4	17.1	0.152
No. 2	5	18.0	0.182
No. 3	5	21.0	0.230
No. 4	6	19.2	0.29

Seeds for germinating rate test were obtained from the Changbai Mountain and Dahailin Migrating Conservation Base of *Rhodiola sachalinensis.* The Base lies in Taipinggou Forest Farm, Dahailin Forestry Bureau, Hailin County, Heilongjiang Province, spanning 44°03'-44°41' N, 128°02'-129°01' E, at the elevation 500 m above sea level. The climate is monsoon climate of temperate zone.

Results and discussion

Frequency distribution of seed dispersal

The investigation result showed that the seed dispersal of *Rh. sachalinensis* is not even in all directions. It concentrates on the North and the East, and is relatively rare on the West and the South. However, the dispersal is still around the cluster. On the east to the cluster, seeds were found spreading from the root to a far distance. An exponential increase in the number of seeds was observed from 80 to 200 cm from the cluster root (see Fig. 1(A)). On the North to the cluster, most of the seeds spread much closer. In the further places, the number of seed fluctuates (see Fig. 1(B)). On the West and South to the cluster, the seeds only spread closely and the number fluctuates as well (see Fig. 1(C, D).

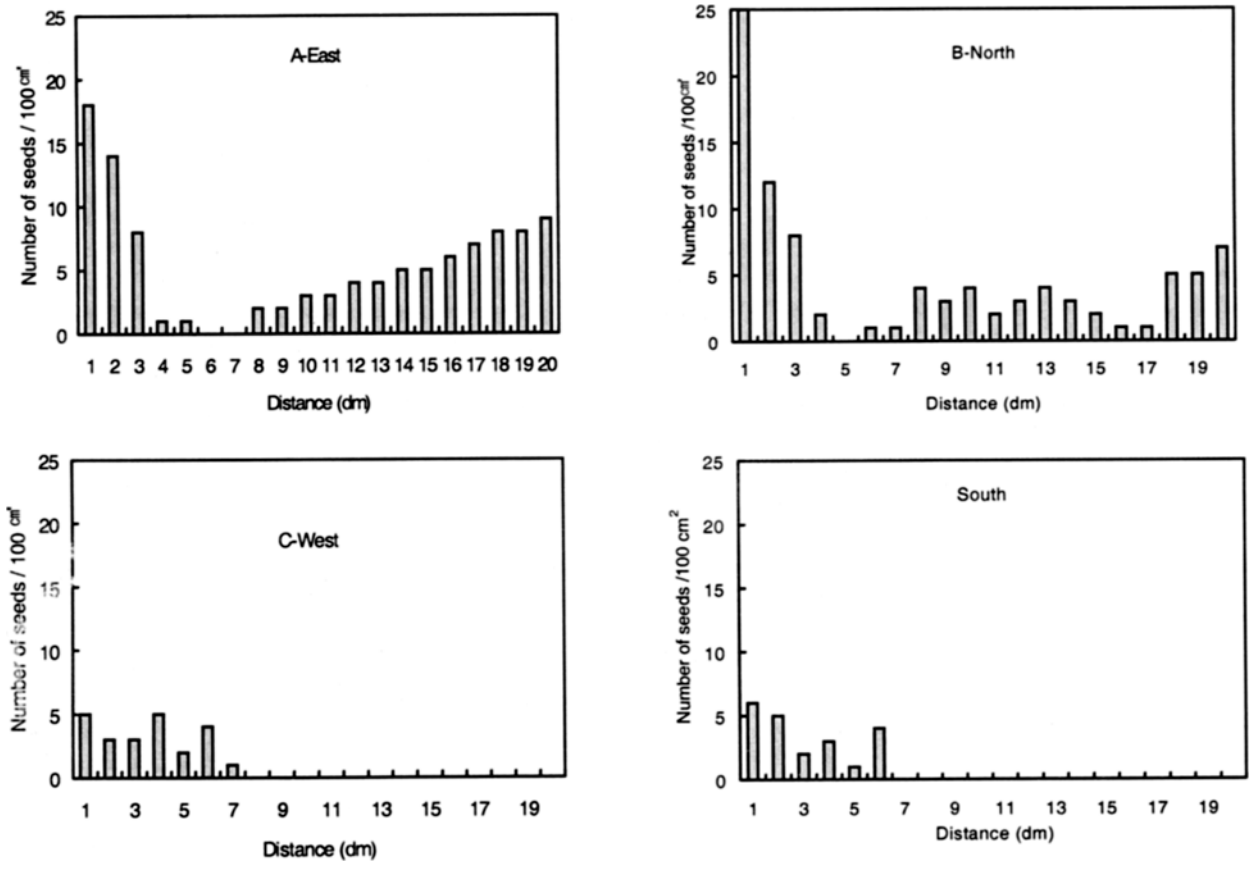

Fig.1 Frequency distribution of *Rhodiola sachalinensis* seeds

By performing the anatomy of pre-matured fruit, investigation of fruit number, and wrapping treatment of fruit before maturation, It was found that only 50% of the seeds dispersed within 2 m around the cluster, 35% retained in the fruits, and the other 15% were taken to somewhere by the strong wind.

Geographical condition is an important factor affecting the dispersal of *Rh. sachalinensis* seeds. Generally, no regular dispersal was discovered because of the effects of wind and landform. It was observed that the seeds of *Rh. sachalinensis* growing on the Changbai Mountains could not spread out because they only grow in rock cracks or leeward places. The seeds were seldom preyed by animals and retained in the same place, but they cannot germinate due to poor conditions of soil and space.

Seed germination

In interspecies, the mean weight of seeds is highly constant. When the growth season become shorter with rising of geographical altitude or elevation, plants should produce less seeds rather than small seeds (Silvertown 1982). The seeds used in this experiment were collected from the Migrating Conservation Base of *Rh. sachalinensis* in Dahailin Forestry Bureau (Heilongjiang Province) and Changbai Mountains area, and the weight per thousand seeds from the two areas was 0.1307 g and 0.1063 g, respectively. The size and productivity of seeds depend on the environmental conditions they are growing in the Changbai Mountain area, the asexual reproduction of *Rh. sachalinensis* was very slow due to the dry and thin soil and awful climate, and it mainly depends on the sexual reproduction to produce seeds and form seedlings, besides, the number of individuals in a cluster was fairly few and the growth was slow for the prohibiting factors. Consequently, with less accumulation of nutrients, the weight of seeds produced was low. In contrast, the seeds harvested in the Migrating Conservation Base (Dahailin area) were much plumper because of the suitable humidity and nutrition. Generally, as big seed contains much water than small ones, the survival probability of big seed is higher than small ones in dry environment. The maturity of seeds collected from the two areas was fairly poor. The rate of plump and matured seed was 65.35% (Dahailin) and 47.60% (Changbai Mountains), respectively. The most suitable temperature and humidity for germination of *Rh. sachalinensis* seeds is 15-20 °C and 50%-70%. It was reported that no significant morphological changes or post morphological maturation was found in different storage period, and that the storage under low temperature and treatment with hormone could increase the germinating rate (Qin 1992).

The period and temperature of storage have significant impact on the germinating rate of seeds. The newly collected seeds decreased significantly in germinating rate after 8 months storage under the temperature of 10-20 °C and all lost the ability of germination after a year. The life of *Rh. sachalinensis* seeds is about one year. Storage under low temperature can improve the germination and prolong the life of seeds to a certain extent. *Rh. sachalinensis* seeds used in our experiment were stored at 0-5°C and for 10 months, but the germinating rate still hits 18%. It was found that treating with the mixture of KNO_3 and GA_3 could increase the germination rate. Dormant seeds of plants showed a higher ability of resisting freezing temperature and accompanied unfavorable condition. Webb (1973) approved that the dormancy of bud and seed was regulated by inner hormones and the level of inner abscisin of dormant seeds fell down during the low temperature treatment. Therefore, low temperature improves the adaptability of seeds on account of ensuring seeds not to germinate before the winter comes or until the spring comes.

Seeds used for germinating test were obtained from Changbai Mountains and Dahailin Migrating Conservation Base. They were treated with 2% KNO_3 for 10h and 0.02% GA_3 for 5h immediately after the collection. The germinating rate was 85.33% in Dahailin Migrating Conservation Base and 72.66% in Changbai Mountains. It indicates that the germinating rate of Dahailin Migrating Conservation Base was higher than the Changbai Mountains area. As mentioned above, sexual reproduction is the major way of reproduction in Changbai Mountain. However, due to the poor natural condition, the height of the cluster was low, and consequently, the weight per thousand seeds was light (0.1063 g). In the Migrating Conservation Base, though asexual reproduction mode is mainly adopted, both the cluster height and the thousand-seed-weight (0.1307 g) were higher than that in Changbai Mountains for suitable natural conditions. *Rh. sachalinensis* seeds had a higher germinating rate in the Daihailin Migrating Conservation Base. This possibly relates to the higher nutrient accumulation in seeds.

The seeds from the Migrating Conservation Base treated with 2% KNO_3 for 10h, and with 0.02%GA_3 for 5h after stored at 0-5℃ for10 months generates a germinating rate by 71%, very similar to that (72.66%) after treated with the same conditions but after the seeds were just collected (Table 2).

Table 2. The germinating rate of *Rhodiola sachalinensis* seeds stored at 0-5℃ for 10 months

Treatment	Germinating rate
2% KNO_3 0.02% GA3	71%
2% KNO_3 0.01% GA3	68%
2%KNO_3	44%
Control (H_2O)	18%

Note: seeds were treated with 2% KNO_3 for 10h, and with 0.02% GA3 and 0.01% GA3 for 5h.

It suggests that storage under low temperature may extend the life of seeds significantly. The germinating rate

increases with increasing of hormone concentration. The rate in control group was only 18%. After treated with 2% KNO_3 for 10h, the rate climbed up to 44%. If they were treated with 0.01% or 0.02% GA_3 for 5h after the treatment with 2% KNO_3, the rate reached 68%-71% (Table 2).

The relationship between seed ecology and endangering status

The seed of *Rh. sachalinensis* is small in both size and weight. The weight per thousand seeds is between 0.10-0.14g. At the top of the seed exists a membrane wing, which functions the seed dispersing with wind. But the wing is too small to carry the seed flying far distance, so the under natural conditions, most the seeds spread around the cluster. Because of the competition of nutrient within a close rang of the cluster, most of seed would not germinate.

Under natural conditions, the germinating rate of *Rh. sachalinensis* seed is very low, only 5%-10%. When the seeds get matured, the climate has been cold enough to prevent them from germinating. However, the seeds of *Rh. sachalinensis* do not necessarily need low-temperature storage. Newly harvested seeds germinate very well in the lab. With the global warmup, the seeds might germinate when they meet warm season or warm winter. Consequently, seedlings will be frozen to death during midwinter. This case brings disadvantage to the conservation of population.

Rh. sachalinensis has strong ability to produce clones. But these clones cannot leave the cluster where they originate and contribute to the extension of population. Seed dispersal is the only way to extend the population. Dispersal pattern and distance of the seeds are the crux of population extension and therefore related to the endangering status of the species.

References

Fu Liguo and Feng Guomei. 1989. The rare and endangered plant species in China [M]. Shanghai:. Shanghai Educational Press.

Fu Liguo, Jin Mingjian. 1992. The red book of China vegetation [M]. Beijing: Science Publishing House.

Qin Jiamei, Zhang Weidong *et.al.*1992. Experimental treatment of *Rhodiola sachalinensis* seeds for domestication growth [J]. Chinese Wild Plants. (3): 43-45.

Qin Ruiming, Wang Di. 1993. Rare and endangered plant species of Heilongjiang Province [M]. Harbin: Northeast Forestry University Press.

Silvertown, J.W. 1982. Introduction to Plant Population Ecology [M]. London and New York: Longman.

Webb, D.P. 1973. Seed production in a natural plant population [J]. Ecology, **56**(2):351-366.

Wu Weichun. 1987. Rhodiola sachalinensis, a rare medicine-plant in Changbai Mountain [M]. Changchun: Jilin Science and Technology Press.

Zhang Xiu. 1993. The medicine values of Rhodiola plants [J]. Wild Plant Resources in China (1): 33-35.

Zhu Ning. 1992. Reproductive ecology of Acnthopannax senticosus: dispersal, bank and generation of seeds [J]. Journal of Northeast Forestry University, **20**(5): 12-17.